J E F F R E Y  L. B R U C E  &  C O M P A N Y


# Green Stormwater Management
# Kansas City Arts Garage Case Study

# Case Study B: Kansas City Arts District Garage

## Kansas City, Missouri, USA

***Developer/Owner:*** City of Kansas City, Missouri
***Design Team:***
Jeffrey L. Bruce & Company
Moody Noland Architects
Reed Hilderbrand
George Butler Engineers
Carl Walker & Associates
***Contractor:*** Walton Construction

***Project Type:*** New Parking Garage
***Completion Date:*** Fall 2011

Water Usage: 1.2 million gallons (4540 $m^3$)

Annual water savings: 84%

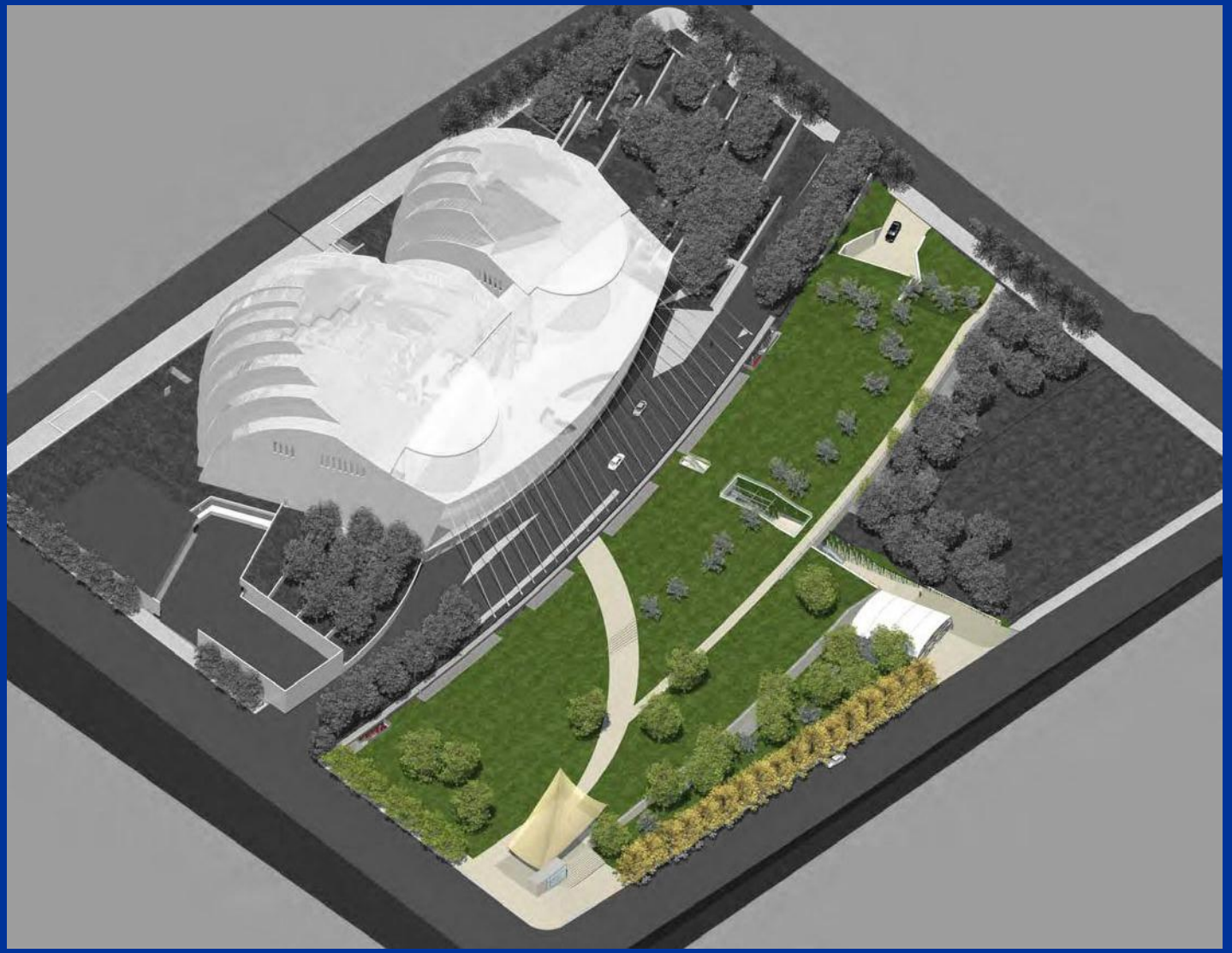
Types of Alternative Water Sources Harvested:

# Kansas City Performing Arts District

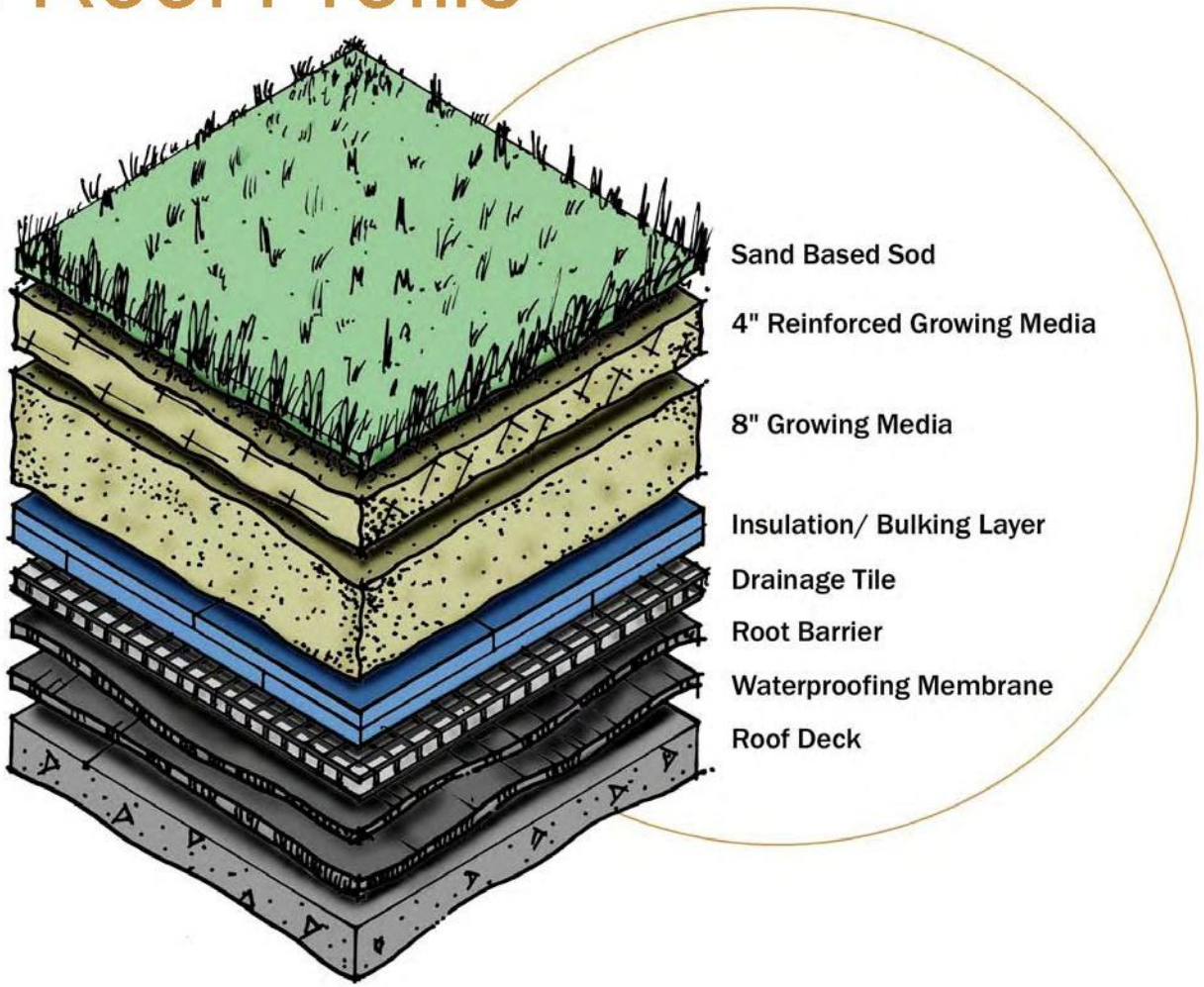
# KCPA Center Facts

- Construction started 2006, Opening **2011**
- **1,800**-seat proscenium-style theatre and **1,700**-seat concert hall
- **285,000** square foot facility on **13** acres
- **1,000** space underground parking garage
- **146,000** square foot green roof over garage
- **47,000** square foot green roof over performing arts structure
- Cost **$413** million

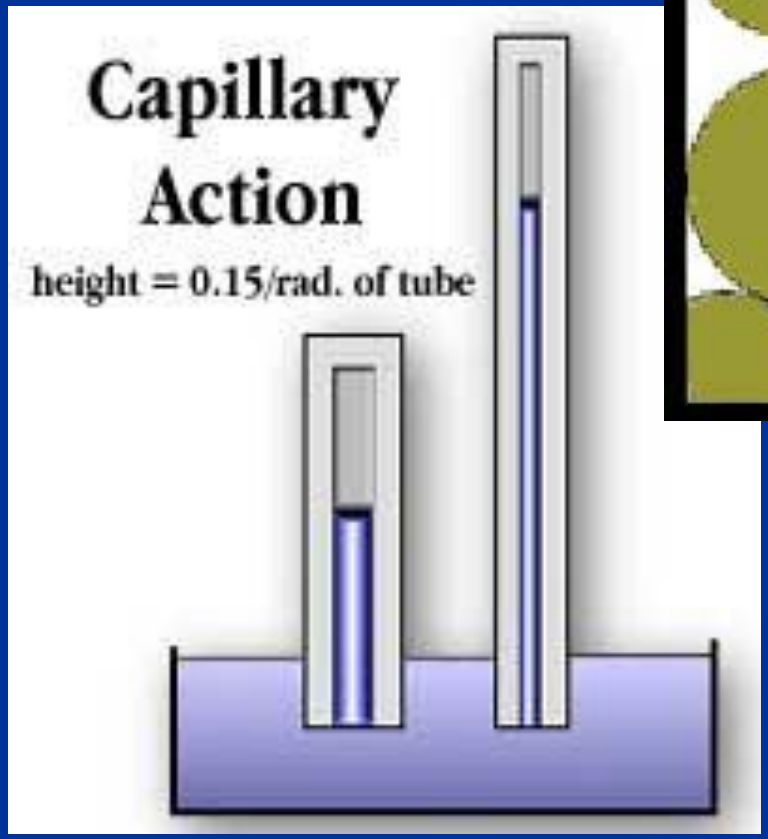
# Kansas City Performing Arts Garage

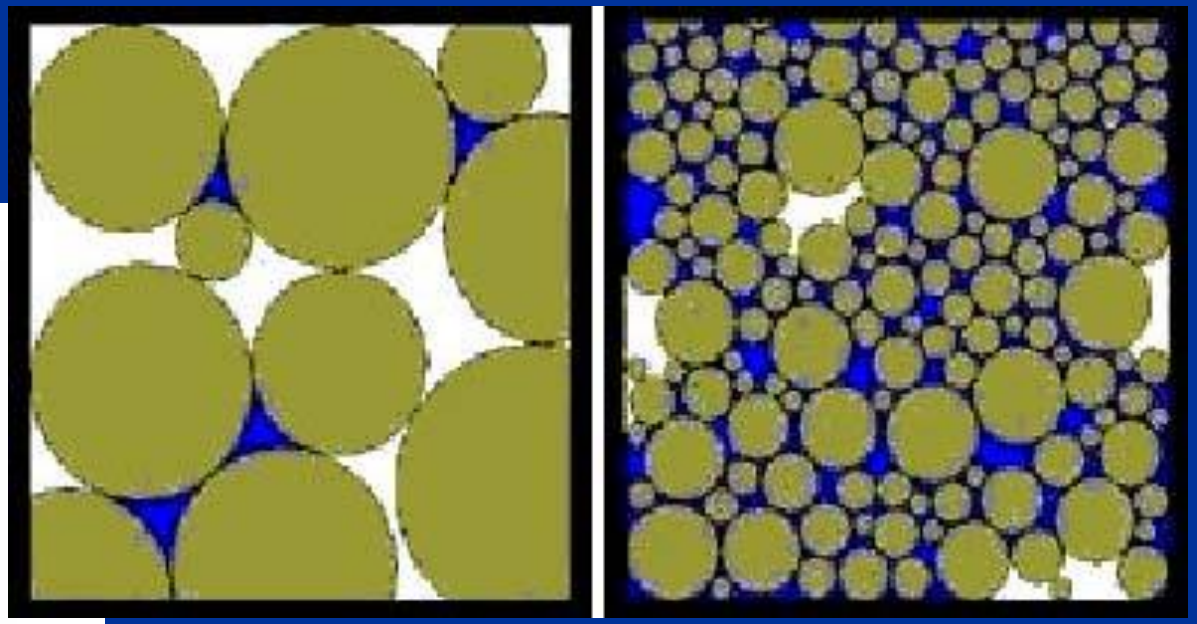


# Green Roof Profile



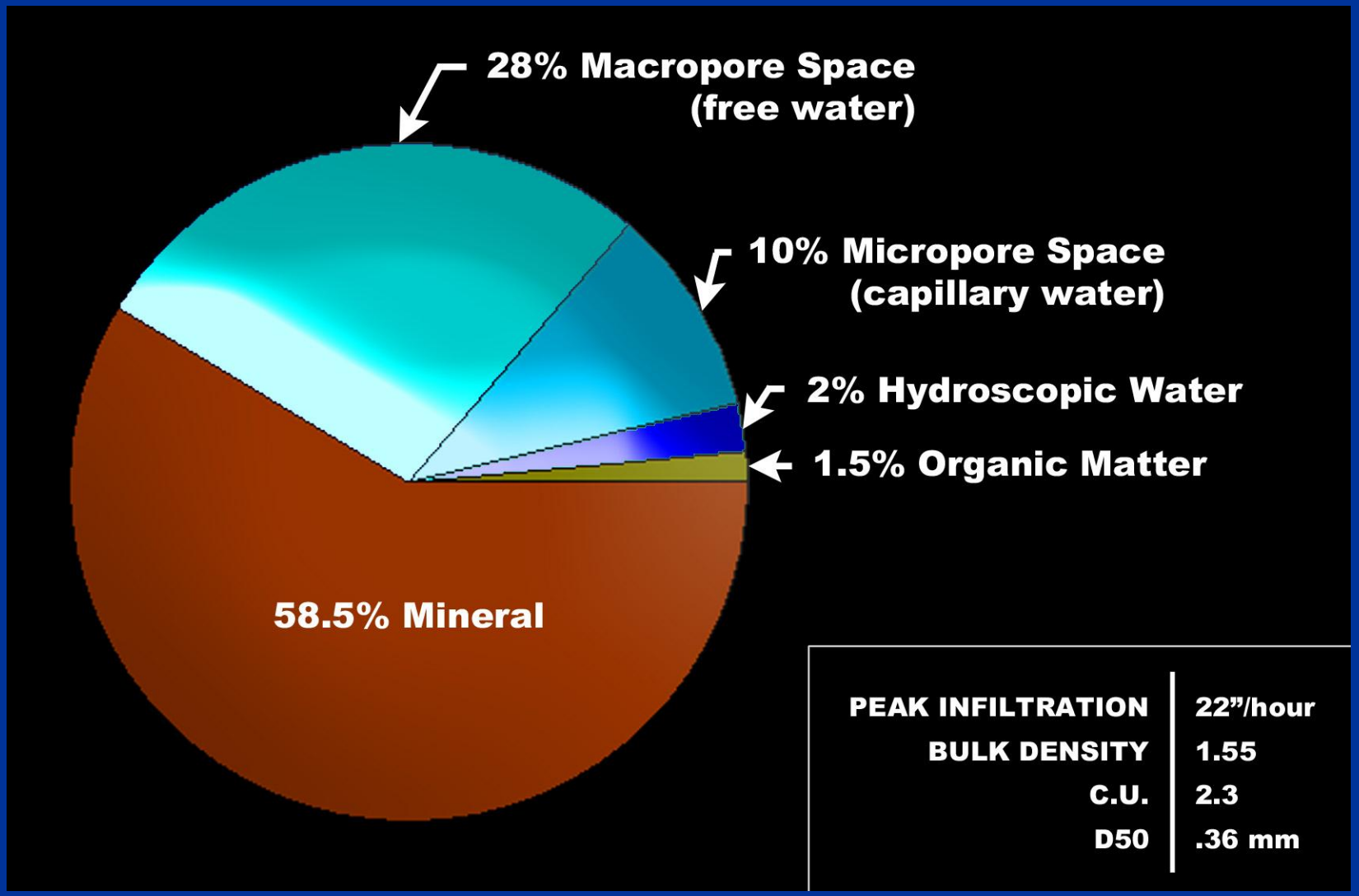
# Capillary Size Effects Water Retention and Flow Rate



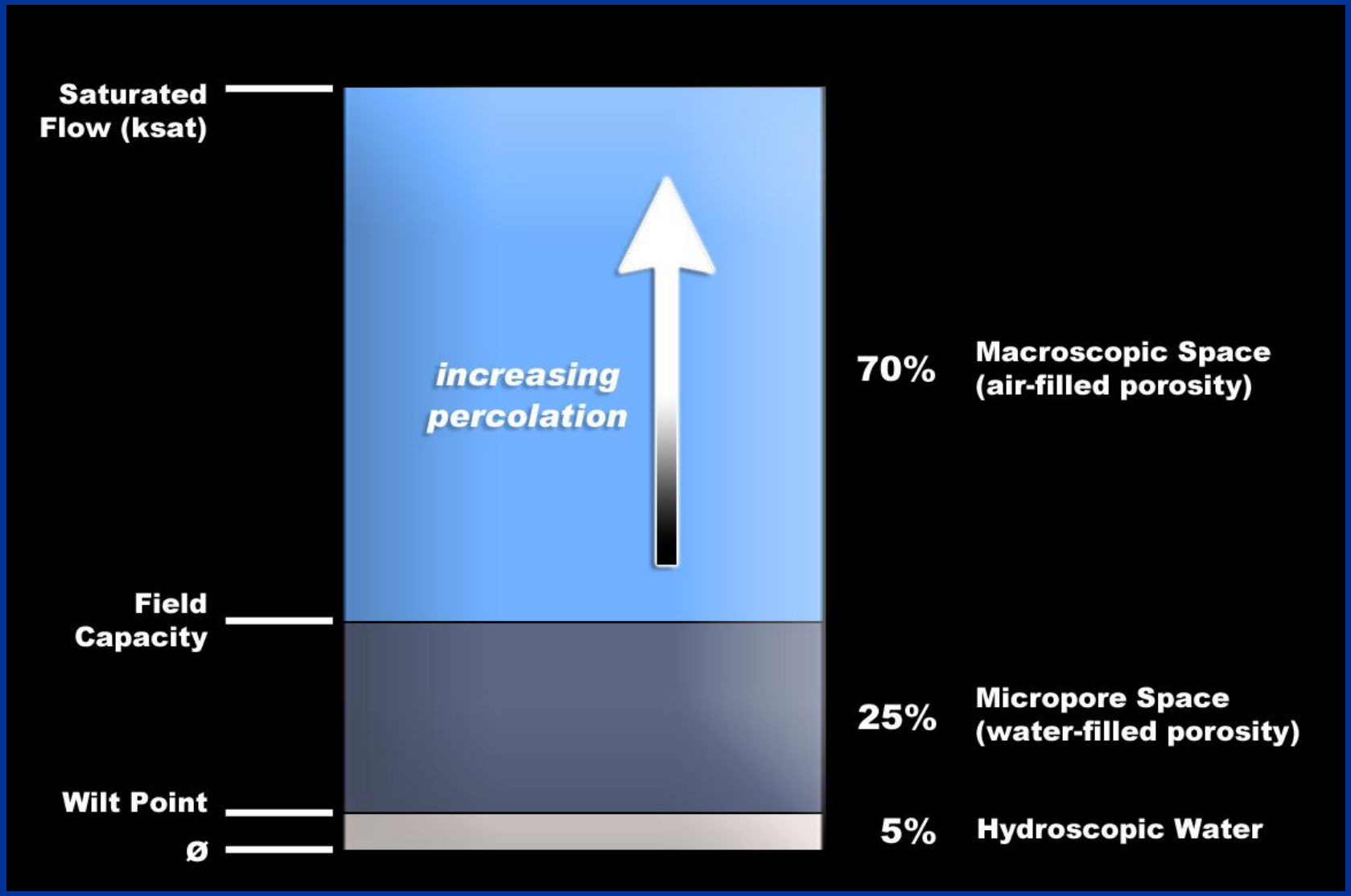
**gravitational water**
**capillary water**
**hygroscopic water**

# KCPA Engineered Soil Composition



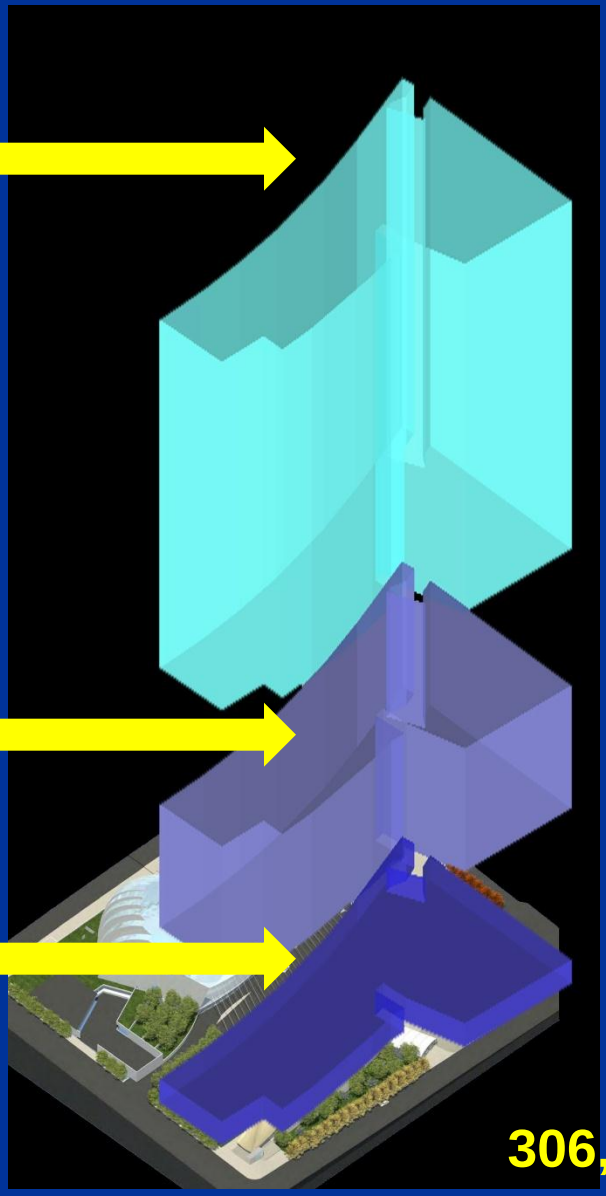

| | |
|---|---|
| PEAK INFILTRATION | 22”/hour |
| BULK DENSITY | 1.55 |
| C.U. | 2.3 |
| D50 | .36 mm |

# KCPA Stormwater Storage Capacity



# KCPA Stormwater Storage Capacity

**Macro Pore Space Volume** → **203,140 gals**



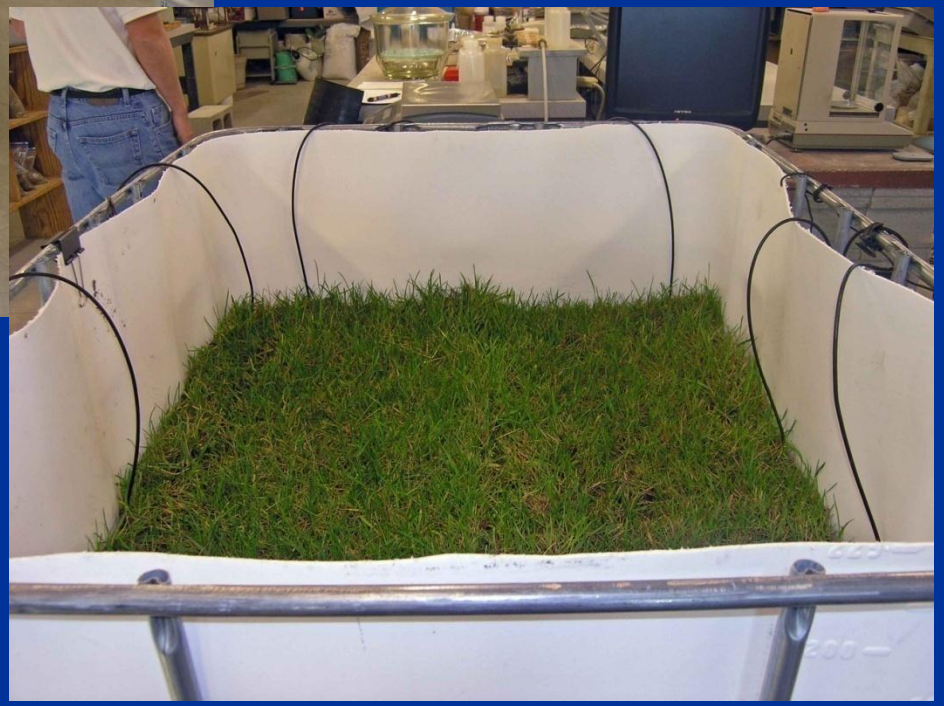
**Micro Pore Space Volume** → **76,563 gals**

**Hydroscopic Water Volume** → **15,307 gals**

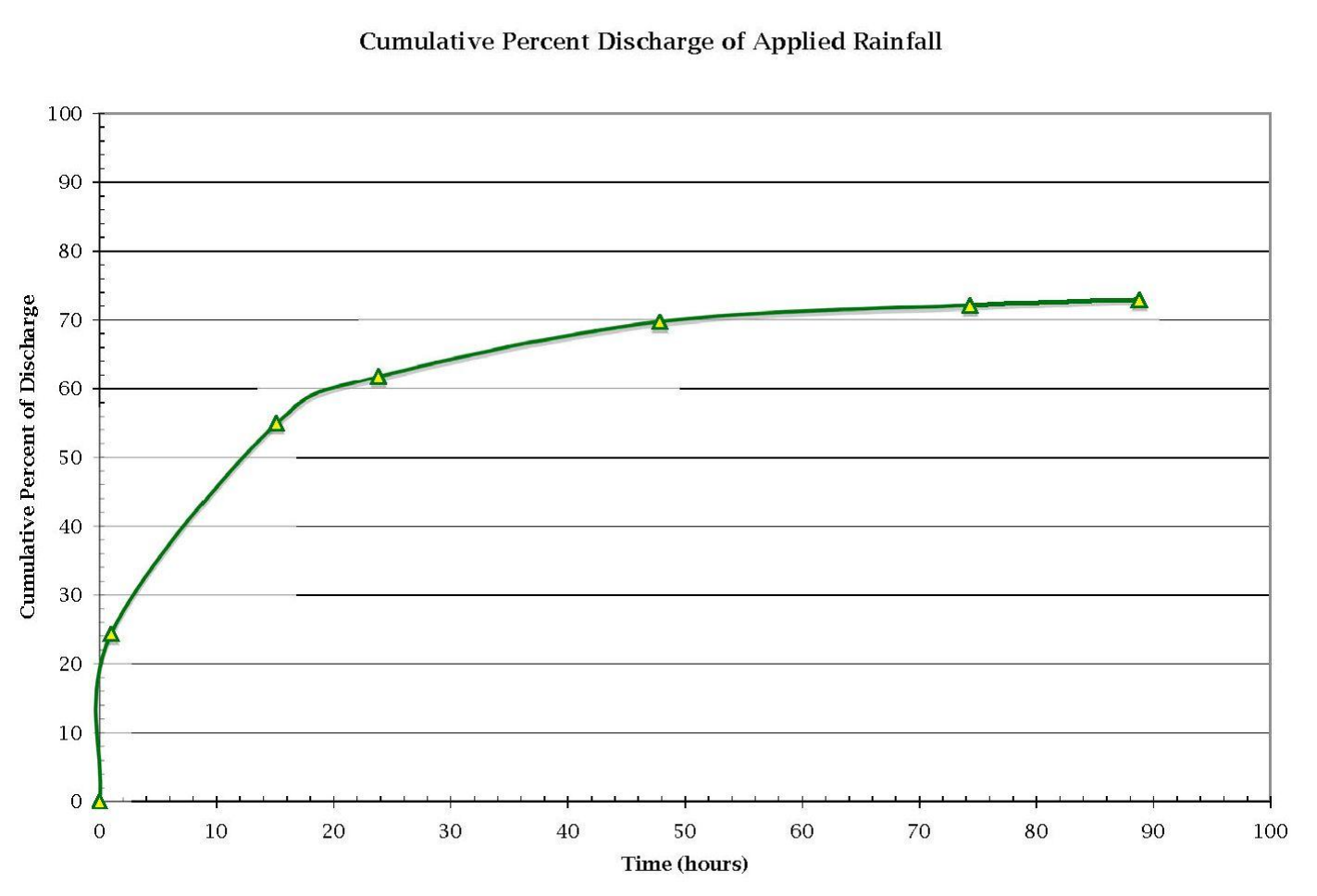
**Green Roof Coverage 146,153 SF**

**306,144 gals total**

# Green Roof Lab Mockup



# Stormwater Buffering Effect




**Simulated 1”rain event (20 minute duration) on a saturated (field capacity)** 8” soil profile

# Regulatory Requirements vs. Performance

Using the Kansas City storm water design parameters which mandate retention of the first **25% of a 100** year storm event, the lab simulated a **3" storm event within a 25 minute** time period, thus exceeding the city requirements.

**50%** of the storm event was retained within the soil profile for the first **12** hours.

**25%** of the storm event was retained within the soil profile for **66** hours before the soil moisture content returned to an unsaturated condition.

# Regulatory Performance

**Pre-construction** runoff quantity was **68** cubic feet per second (cfs)

**Post-construction** runoff quantity required by the city was **35** cubic feet per second (cfs)

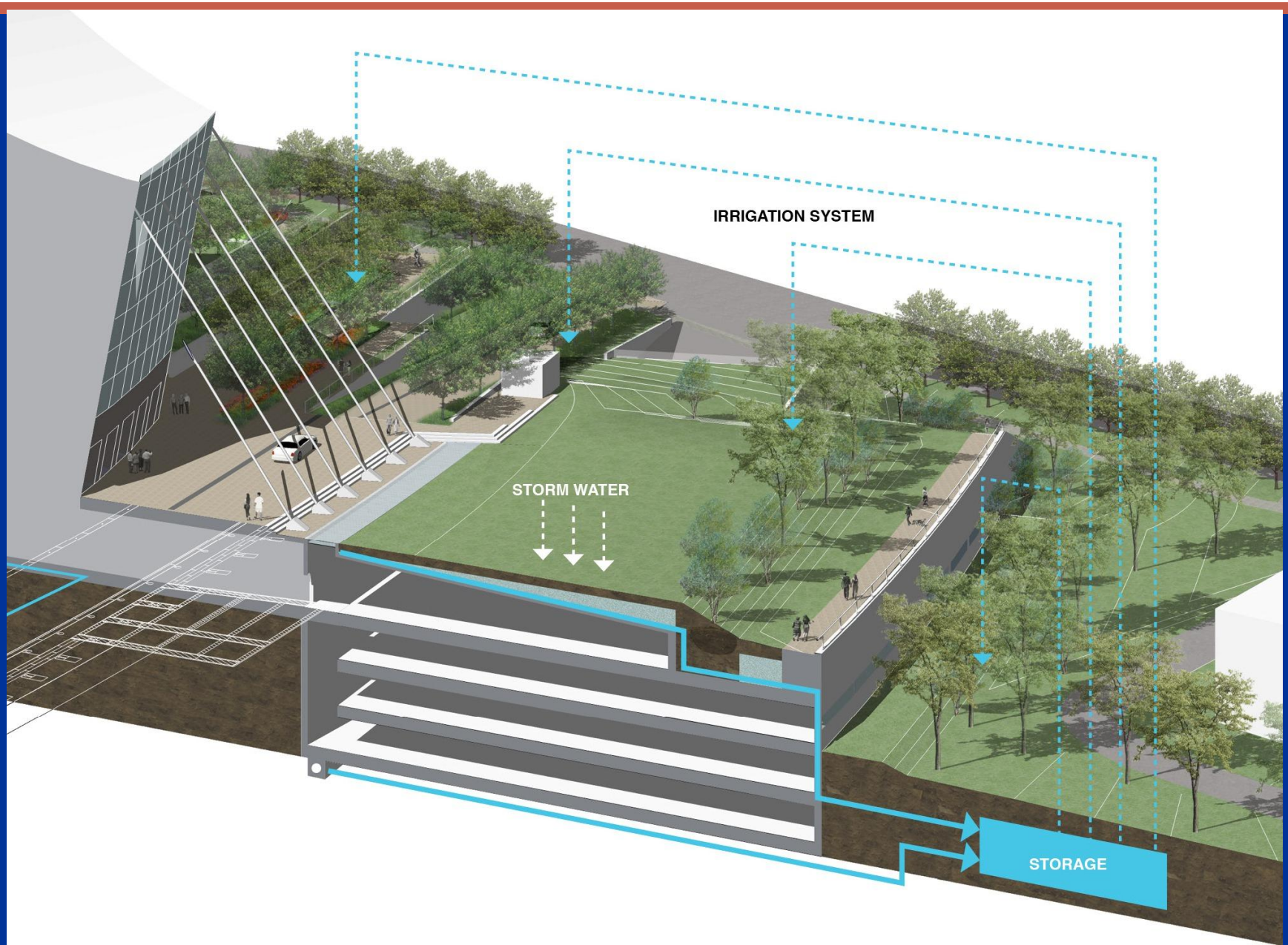
**Green roof** reduced the actual post-construction stormwater quantity to less than **5** cfs

Calculations were conservative and did not include, unsaturated conditions, evapo-transpiration, leaf interception or plant asborption.

# Two 50,000 Gallon Underground Cisterns

# $290,000 Cisterns verse $348,000 for Stormwater Facility

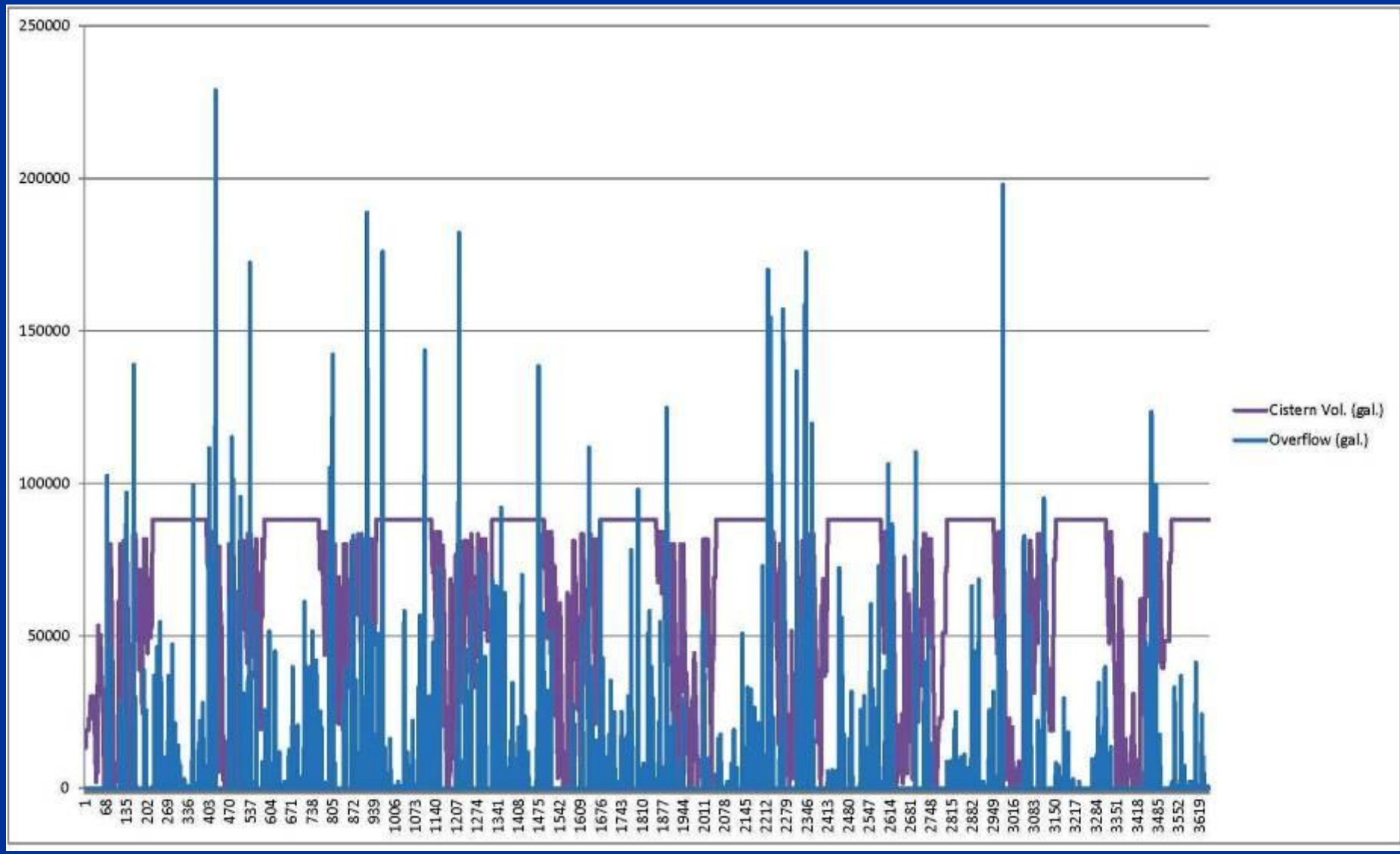
# Rainwater Harvesting System



# Kansas City Performing Arts District

| Performing Arts District Garage<br>Green Roof - Kansas City, Missouri | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Irrigation Monthly Demand** | | | | | | | |
| *Prepared: 22-Nov-11* | | | | | | | |
| # of Days | Description | Gallons | # of Days Watering / Month | Month Rainfall | Daily Rainfall | Percent Usable Rainfall | Month Eto |
| 31 | Total Monthly Demand - January | 0 | 17.7 | 1.15 | 0.0371 | 0.66 | 0.00 |
| | | | | | | | |
| 28 | Total Monthly Demand - February | 0 | 16 | 1.31 | 0.04679 | 0.66 | 1.68 |
| | | | | | | | |
| 31 | Total Monthly Demand - March | 0 | 17.7 | 2.44 | 0.07871 | 0.66 | 3.10 |
| | | | | | | | |
| 30 | Total Monthly Demand - April | 190,307 | 17.14 | 3.38 | 0.11267 | 0.66 | 4.50 |
| | | | | | | | |
| 31 | Total Monthly Demand - May | 143,628 | 17.7 | 5.39 | 0.17387 | 0.66 | 5.27 |
| | | | | | | | |
| 30 | Total Monthly Demand - June | 207,114 | 17.14 | 4.44 | 0.148 | 0.66 | 5.40 |
| | | | | | | | |
| 31 | Total Monthly Demand - July | 249,315 | 17.7 | 4.42 | 0.14258 | 0.66 | 5.89 |
| | | | | | | | |
| 31 | Total Monthly Demand - August | 246,028 | 17.7 | 3.54 | 0.11419 | 0.66 | 5.27 |
| | | | | | | | |
| 30 | Total Monthly Demand - September | 120,565 | 17.14 | 4.64 | 0.15467 | 0.66 | 4.50 |
| | | | | | | | |
| 31 | Total Monthly Demand - October | 0 | 17.7 | 3.33 | 0.10742 | 0.66 | 3.41 |
| | | | | | | | |
| 30 | Total Monthly Demand - November | 0 | 17.14 | 2.3 | 0.07667 | 0.66 | 2.10 |
| | | | | | | | |
| 31 | Total Monthly Demand - December | 0 | 17.7 | 1.64 | 0.0529 | 0.66 | 1.24 |
| | | | | | | | |
| 365 | Annual Water Usage (Irrigation System) | 1,156,957 | 208.57 | 37.98 | | | 42.36 |

# Kansas City Performing Arts District



# Kansas City Performing Arts District

The total annual water use for the KCPAC Garage is just over **1.1 million gallons (4160 $m^3$)**.

The 88,000 gal (333 $m^3$) useable cistern storage captured 37% of total stormwater runoff from the site with an overflow frequency of 59% and a dry cistern frequency of 16%.

The cisterns **supplied 957,763 gallons (3626 $m^3$)** of irrigation demand.

The additional storage of the engineered soil captures 41% of stormwater runoff, a 4% increase from the cisterns alone. Overflow frequency dropped 2% to 57%, and dry cistern frequency dropped 6% to 10%.

# Additional Benefits

Cistern for irrigation usage will save the City an estimated **$52,000** per year in potable water costs

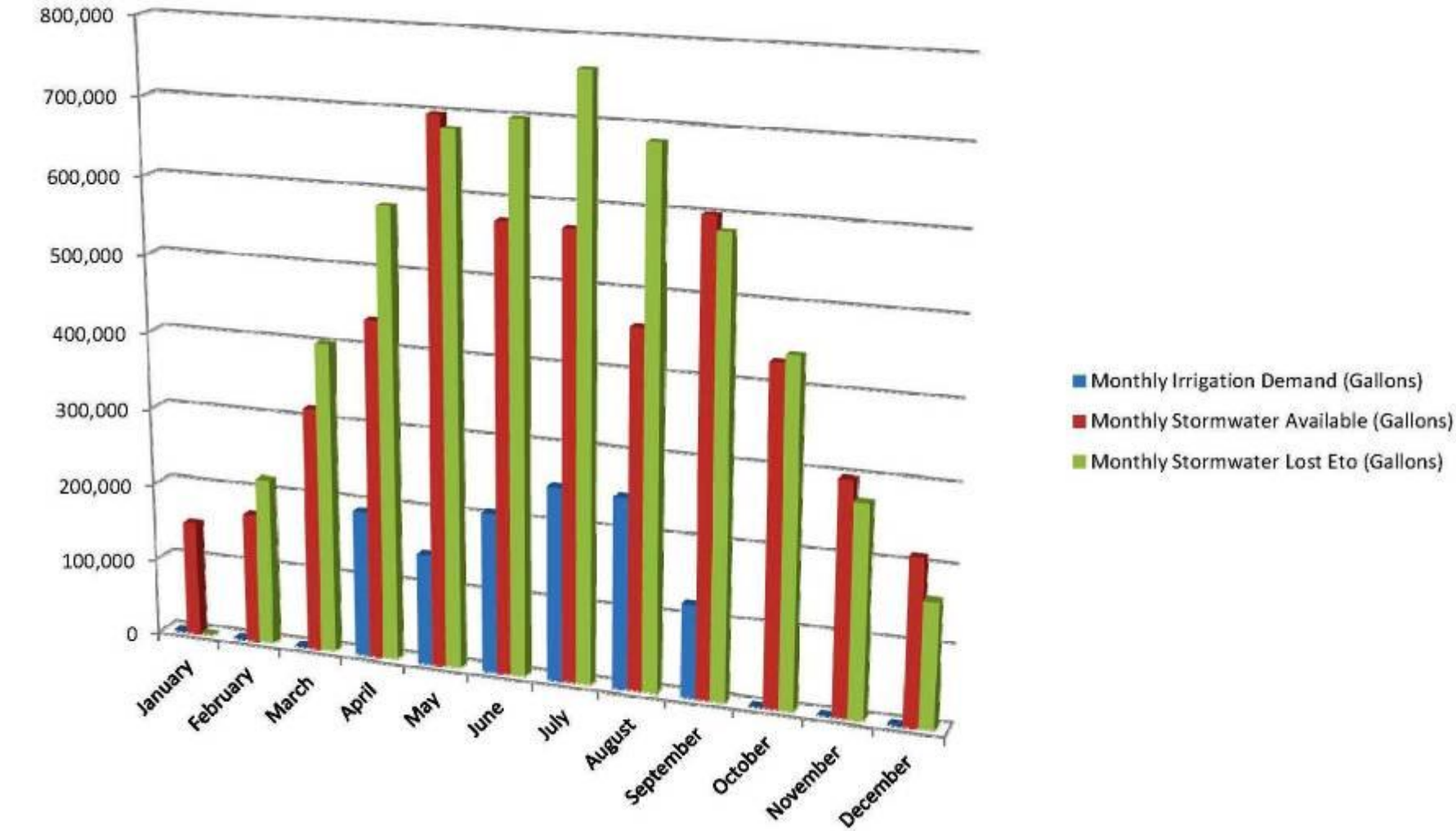
Cost to acquire **2.63** acres of land to provide comparable open space is **$2.8 million** dollars, plus **$485,000** to improve it.

**100,000 gallon cistern** when used for irrigation represents **140 tons of evaporative cooling.**

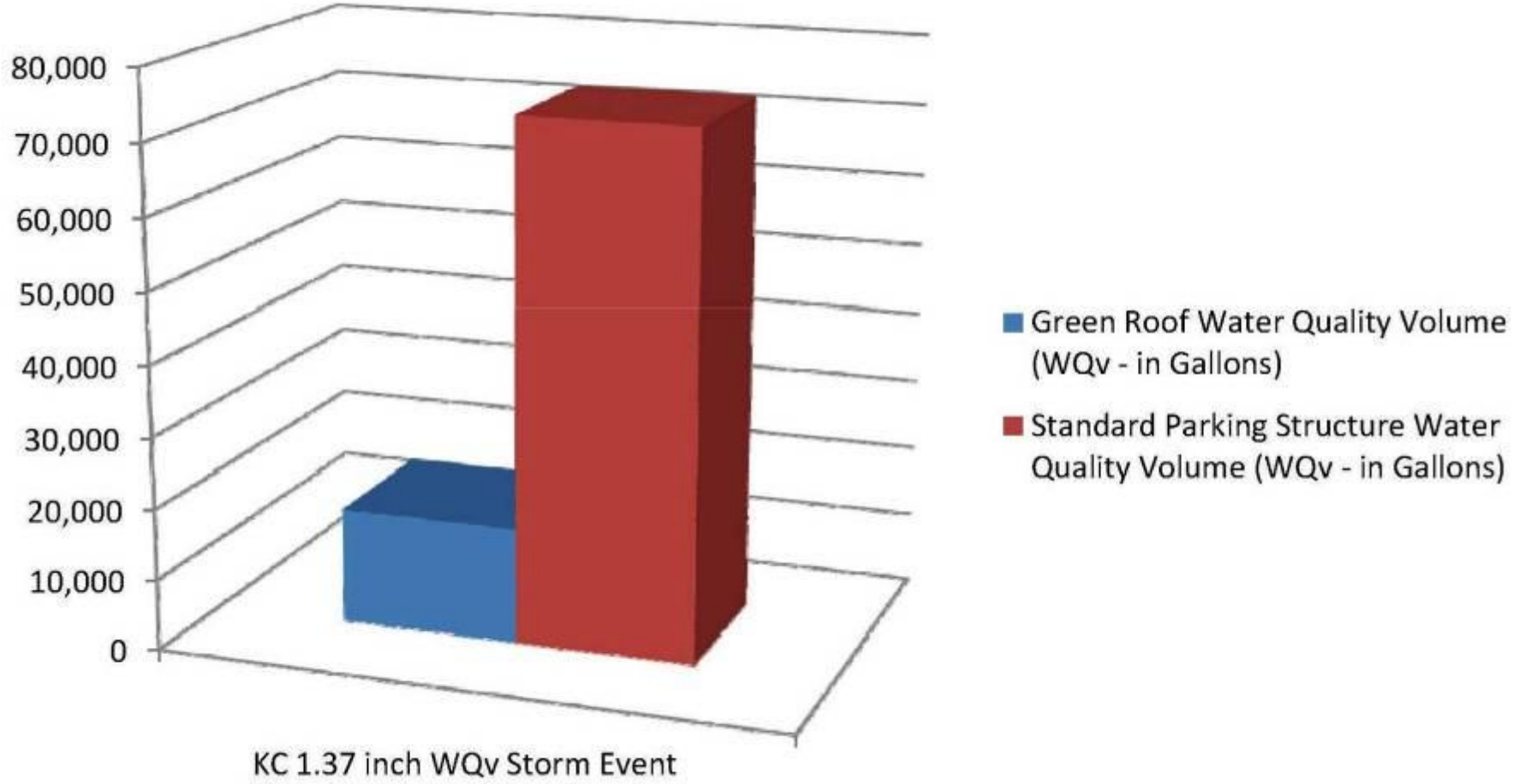
**Evapo-transpiration potential** of the green roof represents the **3865 tons** of evaporative cooling potential on an **annual basis**

**Potential storm water volume reduction** or elimination due to ET is in excess of **2.8** million gallons of water or **8.2 acre-feet** of water on an annual basis.

# Kansas City Performing Arts District



# Kansas City Performing Arts District



# Grey vs. Green Infrastructure Cost Comparison

Functionality of green stormwater metrics such as water quality, volume reduction, beneficial use which **far exceeded the traditional regulatory requirements** for grey infrastructure

Additional **capacity over regulatory compliance** is never calculated, nor is the proposed cost of installation of a traditional grey infrastructure meeting the performance requirements of the completed project

Green stormwater BMP's are integrated into to the design process as a supplemental benefit. **Distinguishing the cost allocation between "stacked" benefits is not precise.**

**Failure in responding is assuming that green infrastructure costs are only attributable to regulatory compliance.**